**Sustainable intensification indicators framework**

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**Introduction**

The SI indicator framework is a decision making tool to improve probability of success for farm and farmer level impact. It aims to be realistic for donor investment and practitioner needs. There are two fundamental questions that, by using these indicators, we are trying to answer about sustainability:

1. How sustainable is this plot / household / community in comparison with other plots / households / communities?
2. If we change something, does the sustainability of the plot / community / household change and, if so, in what way does it change? By monitoring all domains relevant to a project we will be better able to detect synergies and tradeoffs and minimize unintended negative consequences.

It is also important to clarify what this framework is not aiming to achieve

* The framework is **not** intended to define or quantify ‘sustainability’ or pre-determine an ultimate state of sustainability or specific practices that lead to sustainability, but rather to guide decision making, based on evidence-based outcomes, resulting in agricultural systems with improved productivity, environmental, social, and economic outcomes.
* It is **not** intended to cover all dimensions or scales of sustainability but only those commonly focused on by agricultural R&D projects, and it is intended be amendable the development of standardized methods but flexible enough to be adaptable to different scales of interest.
* It is **not** intended to replace other frameworks used by individual programs or projects, but rather to provide a simplified, common framework that facilitates cross-program learning and assessment.
* It is **not** intended to replace adoption studies or identify the best means of up-scaling an intervention. Nevertheless in some contexts it may offer the potential to inform these efforts as well as to inform policy debates related to sustainable intensification.

**Explanation for how the framework could be used**

The following tables show the indicators by domain that are likely to be important when assessing sustainable intensification. The metrics for each indicator are separated by the scale of measurement. Ideally researchers will critically examine the tables and carefully select the indicators and metrics that are most suitable for the specific sustainability assessment considering the unique aspects of the intervention and the bio-physical and socio-economic environment. Below each table we have started making notes about the conditions where each indicators may be applicable. The indicators most likely to be used across interventions and contexts are presented at the top of each table.

The next step will be to develop a guide or protocol detailing how to collect the data needed for each metric. In that section we hope to provide the “gold standard” method for collecting the necessary data as well as potential proxy indicators that may be more feasible. The researcher carrying out the sustainability assessment will have to decide which metrics are worth measuring robustly and which metrics can be estimated more coarsely. We will aim to describe the conditions where the proxy may be useful and where it should not be used.

**Productivity**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Concept | Field/plot (NPP) | Farm | Household | Landscape or Administrative Unit |
| Yield (partitioned by species and tissue type) and residues (total = NPP) | kg (yield, fodder, residue) / ha / season  kg (yield, fodder, residue) / ha / year | kg (yield, fodder, residue) / ha / season  kg (yield, fodder, residue) / ha / year | N/A | Net Primary Productivity (above ground) |
| Fodder production considering quality | Crude protein production / ha  Metabolisable energy production / ha | Crude protein production / ha  Metabolisable energy production / ha | N/A |  |
| Animal productivity considering land area | N/A | Animal production (milk yield, weight gain, meat) / ha grazing and fodder land used  Animal product/farm/year |  | Net commercial off-take relative to the total grazing and fodder production area |
| Variability of yield and animal productivity (over time and space) | Coefficient of variability, distribution, etc. of representative sample | Coefficient of variability, distribution, etc. of representative sample | N/A |  |
| Livestock herd composition | N/A | Heifers per cow  Calves per cow  Oxen per TLU | TLU/ha of farm |  |
| Yield gap (use attainable yield or yield target) | Target – Actual (kg / ha / season) | Target – Actual (kg / ha / season) | N/A | Mean yield compared to maximum observed yield in similar location |
| Cropping intensity (annual count) | Number of crops grown per year (per crop)  Plant population density (seeds/ha/season or seeds/ha year) |  | N/A | # crops grown per year across a landscape  Plant population density of crops within a landscape |

**Notes on productivity indicators:**

* The focus in on yield, partitioned by species and tissue type, in kg/ha/season and year. At a minimum, a better standard for measuring productivity is needed, especially for research projects, and may best be examined by partition among crops to have commodity specific measures of yield.
* The productivity of the land needs to be assessed in terms of all that is produced (not just grain yield), especially where fodder production is significant or where fruit trees are mixed into the landscape.
* Comparisons of productivity across crops (e.g. cotton vs. maize) are difficult unless they are put into a common unit that is meaningful for farmer decision-making (such as local currency if both crops are sold). We need to look into the feasibility of using farmers’ subjective valuation of each crop to assign weights if a large portion of the crops are not sold.
* Farmer recall of harvest is pretty reliable but farmer estimates of area is not very accurate. Measuring is important.
* Fodder production amounts need to be adjusted based on the quality of the fodder
* Animal productivity must be broken down into all the parts of the animal that are used (including manure). Estimating the land area used for grazing or fodder production is likely to be difficult or imprecise.
* Net commercial off take = total sales of region – total purchase into region divided by region herd size
* Yield variability will be more easily interpreted as a percent of total production. It could also be used to estimate the probability of falling below food self-sufficiency or of achieving a production target (break-even point for a cash crop).
* Livestock composition is one way of observing if livestock production is intensifying. A herd with more cows is more commercial as the heifers and calves are more retained by those holding the herd for savings; below 4 TLU per ha can feed on farm
* Yield gap allows for comparison across agro-ecological zones by converting productivity information into the ratio of actual production to the highest observed production in similar conditions. There are limitations to inferences that can be made from this due to strong assumptions about the feasibility of reaching the highest yield.
* Cropping intensity is likely to be important to monitor where the intervention affects the likelihood of irrigation or planting during short season rains.
* Seeding density can be over space and time, more crops and more/less of each crop - it is difficult to interpret yield and SI without knowing population density. So this should always be measured, either as seeds planted and/or ideally as plant population density at harvest.

| Concept | Field/plot | Farm | Household | Landscape or Administrative Unit |
| --- | --- | --- | --- | --- |
| Profitability | Profitability (output sold X price – input costs) | Enterprise budget for livestock  Profitability for all crops | Total agricultural profits per household | Contribution to regional or national GDP |
| Variability of profitability | Yield Risk  Livestock mortality  Price volatility | Probability that  profits < threshold | Probability that  profits < threshold | % hh in community with profits < critical level |
| Income diversification | N/A | Diversification index for all marketable agricultural activities | Diversification index for all income activities |  |
| Input Use Efficiency (water, fertilizer, etc.) | kg output / unit input |  |  |  |
| Limitations of land, labor and capital | Net returns per unit labor input, land input, capital input | Net returns per unit labor input, land input, capital input | % of total labor represented by the peak  % of total expenses represented by the peak (Cash flow constraints) |  |
| Poverty rates (or estimates) | N/A | N/A | Assets, ability to mitigate losses from any one activity with another | Poverty head count  Ag or rural wage/staple food price index  Household expenditure |
| Market participation | N/A | % of production sold (by crop, animal product) | % of total income from agriculture | % households selling an agricultural product |
| Market orientation | N/A | % of land allocated to cash crops | % of total consumption from own production |  |

**Economic**

**Notes on economic indicators**

* The focus is on profitability, variability of profitability and productivity of inputs that may be of critical importance in a particular context.
* Focus on profitability instead of gross agricultural income (cost/benefit analysis, per enterprise, crop etc.) as the former can be easily linked poverty
* Market orientation and Market participation:Market orientation measures the degree to which households produce for sale whereas market participation index measures the degree to which households participate in market as suppliers of their own produce. Bothmeasure the degree of commercialization**.** Commercialization is important to monitor for sustainable intensification because it can have direct links to food security, equity, nutrition and investment in further productivity. Furthermore in some contexts commercialization is a concern as it exposes farmers to price volatility risk. For more details on market orientation see Thom Jayne’s work on a commercialization index
* Returns to labor is related to income which can be linked to consumption and wellbeing.
* Input use efficiency: this is especially important to measure where a specific input is limiting (such as water in some contexts). However, in general it will be better not to over emphasize it but rather focus on output per unit of land (as is done in the productivity domain).
* Poverty rates at various scales have been suggested but may be difficult to measure as poverty is multidimensional. Some of the variables that may be included are: Food consumed at home, food purchases, in-kind food consumption, household demographics (hh size, age, gender), non-food purchases, ownership of durable and productive assets, housing construction, household rentals, asset rentals
* Aggregate to higher levels
* Bio-economic household modeling would be a great tool for looking at profitability, labor limitations, etc.

**Environment Part 1: Vegetation and water**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Concept | Field/plot | Farm | Household | Landscape or Administrative Unit |
| Vegetative Cover | % bare ground (length of time per year)  Months of living cover  % cover of noxious (invasive) plants | % vegetative cover and % tree cover (end of wet season, end of dry season, per year) | N/A | % vegetative and tree cover (end of wet season, end of dry season)  % of animal feed coming from landscape (not farm)  Spatial arrangement of feed sources in landscape |
| Plant Biodiversity | # species – agro-diversity and other diversity  Shannon Diversity | # species (agro-diversity and other diversity)  Shannon Diversity | N/A | % cover of natural habitat for rare species (conservation)  % cover invasive species |
| Fuel | % residues used for fuel | % of manure used for fuel | Time spent obtaining fuel  % of household fuel coming from farm | Spatial arrangement of fuel availability  % of fuel coming from off-farm landscape |
| Water availability | # days without adequate supply of water (rain, irrigation) for crop growth;  # days with too much water (number of days waterlogged during critical crop growth) | Depth to shallow ground water; | # months without adequate supply of clean drinking water within 500m | % hh with year round access to drinking water  % of livestock farmers with year round access to water  % of irrigable land (given current investment) with sufficient irrigation water  % of stream flow not diverted for agriculture or drinking water |
| Water quality | Water salinity level  NO3 level  Zoonotics - #/ml | N/A | Number of months without adequate supply of clean drinking water within 500m | % of water sources (wells, streams) with clean water |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Concept | Field/plot | Farm | Household | Landscape or Administrative Unit |
| Erosion | Estimate changes in components affecting soil loss  C factor (crop type, tillage)  P factor (practice to reduce erosion) |  | N/A | Erosion (t/ha/yr) (MUSLE or RUSLE) |
| Soil C | % C at each soil depth  Carbon budget - Organic matter quantity and quality of inputs (to calculate C) |  | N/A |  |
| Soil acidity | pH and % Al saturation if pH <5 | N/A | N/A |  |
| Soil salinity | EC (electrical conductivity) |  | N/A |  |
| Nutrient Partial Balance | kg N,P, and K inputs (fertilizer, manure, etc.) less kg N, P, and K in total biomass removed (harvest, grazing) per hectare per year | kg N,P, and K inputs (fertilizer, manure, etc.) less kg N, P, and K in total biomass removed (harvest, grazing) per hectare per year | N/A | kg N,P, and K inputs (fertilizer, manure, etc.) – kg N, P, and K in total biomass removed (harvest, grazing) per hectare per year |
| GHG Emissions | CO2 equivalents per hectare (also broken down by CO2, CH4, and N2O). | CO2 equivalents per hectare (also broken down by CO2, CH4, and N2O). | N/A | CO2 equivalents per hectare (broken down into CO2, CH4 and N2O) |

**Environment part 2: Soil and pollution**

**Notes on environmental indicators**

* Each indicator is dependent on scale and time, and need to remain simple despite the potential losses in nuance in remaining simple. The indicators can be specified per context.
* Generally, the percent cover and percent tree cover are inclusive of each level despite needing slightly different metrics between farm and field. They are inclusive of both perennials and non-perennials. As scales increase, species diversity is of greater concern.
* Nutrient balance can be particularly useful to avoid over application of nutrients and the environmental problems associated with it. It is less useful for diagnosing nutrient deficiencies. Phosphorous availability depends on soil type and organic inputs and its recycling is just as important as input and output balances. Nitrogen requires considering amount of biological nitrogen fixation by legumes. Potassium in most systems is adequately available through mineralization of parent material and its importance depends on the particular crop (such as bananas and tobacco).
* Erosion is often measured at landscape level but can be adapted for use at the plot level. Potential soil erosion loss is commonly assessed with the Universal Soil Loss Equation (USLE) as follows:
* A = R x K x LS x C x P With:
* **A** representing the potential long term average annual soil loss in tons per acre per year.
* **R** is the rainfall and runoff factor. The greater the intensity and duration of the rain storm, the higher the erosion potential.
* **K** is the soil erodibility factor. It is the average soil loss in tons/acre per unit area for a particular soil in cultivated, continuous fallow with an arbitrarily selected slope length of 72.6 ft. and slope steepness of 9%. K is a measure of the susceptibility of soil particles to detachment and transport by rainfall and runoff. Texture is the principal factor affecting K, but structure, organic matter and permeability also contribute.
* **LS** is the slope length-gradient factor. The LS factor represents a ratio of soil loss under given conditions to that at a site with the “standard” slope steepness of 9% and slope length of 72.6 feet. The steeper and longer the slope, the higher is the risk for erosion.
* **C** is the crop/vegetation and management factor. It is used to determine the relative effectiveness of soil and crop management systems in terms of preventing soil loss. The C factor is a ratio comparing the soil loss from land under a specific crop and management system to the corresponding loss from continuously fallow and tilled land. The C Factor can be determined by selecting the crop type and tillage method that corresponds to the field and then multiplying these factors.
* **P** is the support practice factor. It reflects the effects of practices that will reduce the amount and rate of the water runoff and thus reduce the amount of erosion. The P factor represents the ratio of soil loss by a support practice to that of straight-row farming up and down the slope. The most commonly used supporting cropland practices are cross slope cultivation, contour farming and strip cropping

**Social**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Concept | Field/plot | Farm | Household | Landscape or Administrative Unit |
| Equity (Gender, Marginalized group) | N/A | % labor for power vs. control activities\*  Rank drudgery from 1 to 10\* | Women Empowerment in Agriculture Index  Access to production factors (mechanization, land)\*  Decision-making about production, marketing (by crop)\* | Variability and distributions of productivity, income and assets\* |
| Level of social cohesion | N/A | N/A | hh participation in community activities  hh receiving help from community, other community, government (bonding, bridging, linking)  Level of integration of family activities | Active farmer groups  Active innovation platforms  % of community participating in some form of social group |
| Level of collective action | N/A | N/A | hh participation in a collective action group | # of collectively managed resource groups that are functioning beyond just existing to meet regulations  # cooperative marketing groups  # labor sharing groups  # problems addressed by innovation platforms  Conflict resolution measures  Capacity of these groups to organize (low staff turnover, transition plans) |
| Conflicts over resources | N/A | N/A | Level of dissatisfaction with household decision-making | # of conflicts over resources |

\* Disaggregated by gender, age, ethnic background

**Notes on Social Indicators:**

* Note from San Jose: The focus depends on the definitions of each indicators despite that the social indicators look at the impact of SI is for gender equality. For example, the goal is to evaluate if SI improves women’s access and use of resources in ways that improve their household and community decision-making power. However, evaluating such a relationship still require definitions of terms such as equity. It may be important to finalize the social theory of change for SI to finalize indicators.
* The Women Empowerment in Agriculture Index survey process may be too demanding for many programs but we will be looking at how to select components from it that can be selected as needed.
* The social cohesion, collective action and conflict indicators need to be developed in terms of the feasible metrics

**Human Condition**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Concept | Field/plot | Farm | Household\* | Landscape or Administrative Unit |
| Nutrition | Diversity of crops grown (disaggregated by consumption versus sale)  kg protein / ha  Micronutrients g/ha | Availability of diverse food crops from own production  kg protein / farm  Micronutrients g/farm | Dietary diversity (individual and household) 24 hour and 7 day recall of protein, iron rich foods and Vitamin A rich foods.  # of children not meeting minimum acceptable diet and minimum meal frequency  Weight for age/height and height for age  Uptake of essential nutrients (Zn, Fe, Vitamin A, Calcium) | Rate of stunting and wasting (large scale development project only)  Market supply of diverse food  Landscape supply of diverse foods (natural areas – not on-farm) |
| Nutrition Awareness |  |  | # of members with adequate knowledge on breastfeeding, complementary feeding, Vitamin A, Iron, Iodine, and other essential nutrients. | % hh with adequate nutrition knowledge |
| Food Safety | Pesticide application #/ha and toxicity/ha |  | Food safety and toxicity (resulting from production, processing and storage)  Aflatoxin contamination of key crops consumed by household (toxicity units per gram)  Pesticide contamination |  |
| Food security | Calories/ ha | Calories/farm (potential food self-sufficiency) | Months without food in hh  Meals/day across seasons  Food security index (various) | Total food production  Total food reserves  Infrastructure (e.g. warehousing, access to markets/roads, irrigation; dependent on geography)  Enabling trade policies |
| Capacity to experiment |  | # of new practices being tested |  | Number of farmers experimenting |

\* Disaggregated by gender, age, ethnic background

**Notes on human condition indicators:**

* Note from San Jose: For the human domain, population level data is possible across households and communities, through census style survey. Farm-level data collection is possible if using the same collection tools towards the same measures and indicators. Basic assumptions: Availability of diverse foods 🡪 Equitable Access (at markets)🡪 Uptake of nutrients (level of disease and health e.g. suffering from worms or aflatoxins then can’t take in nutrients).
* For micronutrient production use look up tables of nutrient content based on kg crop produced
* Anthropometric measures are only suggested for large scale development projects with sufficient time and sample size to detect this
* We have yet to fully explore all of the relevant food security index tools. For example there is a FANTA tool for FS assessment, FAO also has one
* Farmer capacity is a recent addition to the framework and we have yet to explore the best ways to measure this